*Chemistry > Big idea CSU: Substances and properties > Topic CSU3: Acids and alkalis*

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| **Key concept (age 11-14)** |
| **CSU3.1: pH scale** |

**What’s the big idea?**

A big idea in chemistry is that of substances and properties. All materials are made of a single chemical substance or a mixture of substances. Properties of substances may be explained using the big idea of particles and structure.

**How does this key concept develop understanding of the big idea?**

This key concept helps to develop the big idea by introducing acids and alkalis as types of substance in solution that may be compared using the pH scale.

****The conceptual progression starts by checking understanding of acids, alkalis and indicators. It then supports the development of understanding of the pH scale and in order to enable comparison of solutions with different pH.

**Using the progression toolkit to support student learning**

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

**Progression toolkit: pH scale**

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| **Learning focus** | Acidic and alkaline solutions may be compared using the pH scale. | | | | |
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| **As students’ conceptual understanding progresses they can:** | **C o n c e p t u a l p r o g r e s s I o n** | | | | |
| Describe how to find out, safely, whether a solution is an acid. | Identify and give examples of alkalis. | Describe what information an indicator provides. | Interpret the pH scale | Compare acidity or alkalinity using the pH scale.  **B** |
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| **Diagnostic questions** | Identifying acids | Identifying alkalis | Indicators | pH scale | Comparing pH |
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| **Response**  **activities** |  | Drain cleaner |  | Which pH? | Unusual scales |

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| Key: | | | |
| **P** | Prior understanding from earlier stages of learning | **B** | Bridge to later stages of learning |

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| **Identifying acids** | **Identifying alkalis** | **Indicators** | **pH scale** | **Comparing pH** |
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| Talking heads | Confidence grid | Talking heads | Talking heads | Simple multiple choice |
| **Drain cleaner** | **Which pH?** | **Unusual scales** |  |  |
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| Talking heads | Application and practice | Clarifying- worked example |  |  |

**What’s the science story?**

Acids and alkalis are both types of aqueous solution with specific chemical properties. They are indistinguishable by observation as they form colourless solutions. The colour change of litmus indicator may be used to find out whether a solution is acidic or alkaline.

The pH scale indicates how acid or alkaline a solution is.

**What does the research say?**

A variety of research reveals student misunderstandings about the pH scale, including that it is as measure of acidity only (Cros et al., 1986) and that it is linear (pH 1 being two times and not ten times as acidic as pH2) (Sheppard, 2006). Lack of familiarity with alkalis was another problem area for some students with Cros et al (1986) finding that even in the first year of university students could name more acids than alkalis.

Driver (1994) reports research that found that initially students’ perceptions of acids often arise from their own sensory experiences or what they hear or read in the media. The opening of the progression therefore aims to find out more about students’ existing familiarity with acids and alkalis.

A major student conception found by Hand and Treagust (1989) was that ‘acids eat materials away’. This may explain another widely held idea, that the only way to test whether a solution is acidic is to find out if it will eat something away. For this reason, the use of litmus indicator features from the outset in the progression. This is followed by a check for common misunderstandings relating to indicators such as ‘all indicators change colour at pH 7’ and ‘the colour comes from the acid or alkali and not the indicator’. (Nakhleh and Krajcik, 1994).

The progression ends by checking both qualitative and quantitative understanding of the pH scale in terms of the relative acidity and alkalinity of different pH numbers.

**Guidance notes**

The challenge in early teaching about the pH scale is that ideas relating to hydrogen ion concentration, strong and weak acids and logarithmic scales are not introduced until much later so the topic must be simplified. Some misunderstandings revealed by the research may be linked with student recollection of their early experiences of the topic so care must be taken to minimise the introduction of later misconceptions.

This key concept suggests possible uses of language to help with this. For example, pH is described as being more acidic than pH 2 (not as being a stronger acid than pH 2). The use of litmus indicator to distinguish acids from alkalis is made clear rather than a generic use of the word indicator because indicators that students may meet later do not necessarily change colour at pH 7.

Although the idea of logarithms is unlikely to be introduced in mathematics until a much older age students may still be made aware that the pH scale is not linear and that pH1 is actually ten times as acidic as pH2. The response activity ‘Unusual scales’ may be used to support this.

**References**

Cros, D. é., et al. (1986). Conceptions of first-year university students of the constituents of matter and the motions of acids and bases. *European Journal of Science Education,* 8(3)**,** 305-313.

Driver, R., et al. (1994). *Making Sense of Secondary Science: Research into Children's Ideas,* London, UK: Routledge.

Hand, B. and Treagust, D. F. (1989). Application of a conceptual conflict teaching strategy to enhance student learning of acids and bases. *Research in Science Education,* 19**,** 133-144.

Nakhleh, M. B. and Krajcik, J. S. (1994). Influence of levels of information as presented by different technologies on students' understanding of acid, base and pH concepts. *Journal of Research in Science Teaching,* 31(10)**,** 1077-1096.

Sheppard, K. (2006). High school students' understanding of titrations and related acid-base phenomena. *Chemistry Education Research and Practice,* 7(1)**,** 32-45.